Q 1		mark		sub
	either 70V obtained So $70V = 1400$ and $V = 20$ or V = 20	M1 A1 M1 A1 M1 A1 M1 A1	Attempt at area. If not trapezium method at least one part area correct. Accept equivalent. Or equivalent – need not be evaluated. Equate <b>their</b> 70 <i>V</i> to 1400. Must have attempt at complete areas or equations. cao Attempt to find areas in terms of ratios (at least one correct) Correct total ratio – need not be evaluated. (Evidence may be 800 or 400 or 200 seen). Complete method. (Evidence may be 800/40 or 400/20 or 200/10 seen). cao	
				4

Q 2		mark		sub
	$(v =)12 - 3t^{2}$ $v = 0 \Rightarrow 12 - 3t^{2} = 0$ so $t^{2} = 4$ and $t = \pm 2$ $x = \pm 16$	M1 A1 M1 A1 A1	Differentiating Allow confusion of notation, including $x =$ Dep on 1 <sup>st</sup> M1. Equating to zero. Accept one answer only but no extra answers. FT only if quadratic or higher degree. cao. Must have both and no extra answers.	
				5

Q 3		mark		sub
(i)	<i>R</i> = <i>mg</i> so 49 N	B1	Equating to weight. Accept 5g (but not mg)	1
(ii)	$F \leftarrow \begin{array}{c} \mathbf{R} \\ 40^{\circ} \\ 40^{\circ} \\ 49 \text{ N} \end{array} $	B1 B1	All except <i>F</i> correct (arrows and labels) (Accept <i>mg</i> , <i>W</i> etc and no angle). Accept cpts instead of 10N. No extra forces. <i>F</i> clearly marked and labelled	2
(iii)	$\uparrow R + 10\cos 40 - 49 = 0$ R = 41.339  so  41.3  N  (3  s. f.) $F = 10\sin 40 = 6.4278 \text{ so } 6.43 \text{ N } (3 \text{ s. f.})$	M1 B1 A1 B1	Resolve vertically. All forces present and 10N resolved Resolution correct and seen in an equation. (Accept $R = \pm 10 \cos 40$ as an equation) Allow –ve if consistent with the diagram.	4
				7

	mark		sub
$\downarrow  20 + 16\cos 60 = 28$	B1		1
either $\rightarrow 16 \sin 60$	B1 M1	Any form. May be seen in (i). Accept any appropriate equivalent resolution. Use of Pythag with 2 distinct cpts (but not 16 and $\pm 20$ )	
Mag $\sqrt{28^2 + 192} = 31.2409$ so 31.2 N (3 s.f.) or Cos rule mag <sup>2</sup> = 16 <sup>2</sup> + 20 <sup>2</sup> - 2×16×20×cos120 31.2 N (3 s. f.)	F1 M1 A1 A1	Allow 34.788 only as FT Must be used with 20 N, 16 N and 60° or 120° Correct substitution	3
Magnitude of accn is 15.620 m s <sup>-2</sup> so 15.6 m s <sup>-2</sup> (3 s. f.) angle with 20 N force is $\arctan\left(\frac{16\sin 60}{28}\right)$ so 26.3295 so 26.3° (3 s. f.)	B1 M1 A1	Award only for <b>their</b> $F$ ÷2 Or equiv. May use force or acceleration. Allow use of sine or cosine rules. FT only $s \leftrightarrow c$ and sign errors. Accept reciprocal of the fraction. cao	3
			7
	mark		sub
sphere $19.6 - T = 2a$ block $T - 14.8 = 4a$	M1 A1 A1	N2L. All forces attempted in one equation. Allow sign errors. No extra forces. Don't condone $F = mga$ . Accept 2g for 19.6	
Solving <i>T</i> = 18 <i>a</i> = 0.8	M1 A1 F1	Attempt to solve. Award only if two equations present both containing <i>a</i> and <i>T</i> . Either variable eliminated. Either found cao Other value. Allow wrong equation(s) and wrong working for 1 <sup>st</sup> value [If combined equation used award: M1 as in (i) for the equation with mass of 6 kg; A1 for $a = 0.8$ ; M1 as in (i) for equation in <i>T</i> and <i>a</i> for either sphere or block; A1 equation correct; F1 for <i>T</i> , FT <b>their</b> <i>a</i> ; B1 Second equation in <i>T</i> and <i>a</i> .]	3
	↓ 20+16cos 60 = 28 either → 16sin 60 Mag $\sqrt{28^2 + 192} = 31.2409$ so 31.2 N (3 s.f.) or Cos rule mag <sup>2</sup> = 16 <sup>2</sup> + 20 <sup>2</sup> - 2×16×20×cos 120 31.2 N (3 s. f.) Magnitude of accn is 15.620 m s <sup>-2</sup> so 15.6 m s <sup>-2</sup> (3 s. f.) angle with 20 N force is $\arctan\left(\frac{16\sin 60}{28}\right)$ so 26.3295 so 26.3° (3 s. f.) sphere 19.6- <i>T</i> = 2 <i>a</i> block <i>T</i> -14.8 = 4 <i>a</i> Solving <i>T</i> = 18 <i>a</i> = 0.8	↓       20+16cos 60 = 28       B1         either       →       16sin 60       B1         Mag $\sqrt{28^2 + 192} = 31.2409$ B1         so       31.2 N (3 s.f.)       F1         or       Cos rule       M1         mag <sup>2</sup> = 16 <sup>2</sup> + 20 <sup>2</sup> - 2 × 16 × 20 × cos 120       A1         31.2 N (3 s. f.)       A1         Magnitude of accn is 15.620 m s <sup>-2</sup> B1         so 15.6 m s <sup>-2</sup> (3 s. f.)       angle with 20 N force is $\arctan\left(\frac{16 \sin 60}{28}\right)$ M1         so 26.3295 so 26.3° (3 s. f.)       A1         Image:       Image:       M1         so phere       19.6 - T = 2a       A1         block       T - 14.8 = 4a       A1         Solving       M1       A1	mark $\downarrow$ 20+16cos 60 = 28B1either $\rightarrow$ 16sin 60B1Any form. May be seen in (i). Accept any appropriate equivalent resolution. Use of Pythag with 2 distinct cpts (but not 16 and $\pm$ 20)Mag $\sqrt{28^2 + 192} = 31.2409$ so 31.2 N (3 s.f.)B1Allow 34.788 only as FT Must be used with 20 N, 16 N and 60° or 120° Correct substitutionor Cos rule mag <sup>2</sup> = 16 <sup>3</sup> + 20 <sup>2</sup> - 2 × 16 × 20 × cos 120 31.2 N (3 s. f.)B1Magnitude of acon is 15.620 m s <sup>-2</sup> so 15.6 m s <sup>-2</sup> (3 s. f.)B1Award only for their $F + 2$ or cosine rules. FT only $s \leftrightarrow c$ and sign errors. Accept reciprocal of the fraction. caoso 26.3295 so 26.3° (3 s. f.)A1markM1Sphere 19.6 - $T = 2a$ block $T - 14.8 - 4a$ M1N2L.All forces attempted in one equation. Allow sign errors. No extra forces. Don't condone $F = mga$ . Accept $2g$ for 19.6SolvingM1Attempt to solve. Award only if two equations present both containing $a$ and $T$ . Either variable elliminated. Either rule $A$ allow if $a$ and $b$ in $(i)$ for the equation with mass of $6$ kg; A1 for $a = 0.8$ ; M1 as in (i) for equation in $T$ and $a$ ]

Q 6		mark		sub
(i)	$t = 2.5 \Rightarrow \mathbf{v} = \begin{pmatrix} -5\\10 \end{pmatrix} + 2.5 \begin{pmatrix} 6\\-8 \end{pmatrix} = \begin{pmatrix} 10\\-10 \end{pmatrix}$ $45^{\circ}$	B1 E1	Need not be in vector form Accept diag and/or correct derivation of just $\pm 45^{\circ}$	
	speed is $\sqrt{10^2 + 10^2} = 14.14$ so 14.1 m s <sup>-1</sup> (3 s. f.)	F1	FT their v	3
(ii)	$\mathbf{s} = 2.5 \begin{pmatrix} -5\\10 \end{pmatrix} + \frac{1}{2} \times 2.5^2 \times \begin{pmatrix} 6\\-8 \end{pmatrix}$ $= \begin{pmatrix} 6.25\\0 \end{pmatrix}$ so 090°	M1 A1 A1 A1	Consideration of <b>s</b> (const accn or integration) Correct sub into <i>uvast</i> with <b>u</b> and <b>a</b> . (If integration used it must be correct but allow no arb constant) cao. CWO.	4
				7

Q 7		mark		sub
(i)	acceleration is $\frac{24}{12}$ so 2 m s <sup>-2</sup>	B1		1
(ii)	24-15 = 12a $a = 0.75 \text{ m s}^{-2}$ $1^{\text{st}}$ distance is $0.5 \times 2 \times 16 = 16$ $2^{\text{nd}}$ distance is $0.5 \times 0.75 \times 16 = 6$ Difference is 10 m	M1 A1 M1 A1 A1	Use of N2L. Both forces present. Must be $F = ma$ . No extra forces. Appropriate <i>uvast</i> applied at least once. Need not evaluate. Both found. May be implied. FT (i) cao	5
(iii)	$12g\sin 5 - 15 = 12a$ a = -0.39587 so $-0.396$ m s <sup>-2</sup> (3 s. f.)	M1 M1 A1 A1	Use of $F = ma$ , allow 15 N missing <i>or</i> weight not resolved. No extra forces. Allow use of $12 \sin 5$ . Attempt at weight cpt. Allow $\sin \leftrightarrow \cos$ . Accept seen on diagram. Accept the use of 12 instead of 12 <i>g</i> . Weight cpt correct. Accept seen on diagram. Allow not used. Correct direction must be made clear	
(iv)	time $0 = 1.5 + at \Rightarrow t = 3.789$ so $3.79 \text{ s} (3 \text{ s. f.})$ distance $s = 0.5 \times (1.5 + 0) \times 3.789 \text{ (or)}$ giving $s = 2.8418$ so $2.84 \text{ m} (3 \text{ s. f.})$	M1 A1 M1 A1	Correct <i>uvast</i> . Use of 0, 1.5 and <b>their</b> <i>a</i> from (iii) or <b>their</b> <i>s</i> from (iv). Allow sign errors. Condone $u \leftrightarrow v$ . Correct <i>uvast</i> . Use of 0, 1.5 and <b>their</b> <i>a</i> from (iii) or <b>their</b> <i>t</i> from (iv). Allow sign errors. Condone $u \leftrightarrow v$ . [The first A1 awarded for <i>t</i> or <i>s</i> has FT <b>their</b> <i>a</i> if signs correct; the second awarded is cao]	4
(v)	accn is given by $0 = 1.5 + 3.5a \Rightarrow a = -\frac{3}{7} = -0.42857$ $12g \sin 5 - R = 12 \times -0.42857$ so $R = 15.39$ so $15.4$ N (3 s. f.)	M1 A1 M1 A1	Use of 0, 1.5 and 3.5 in correct <i>uvast</i> . Condone $u \leftrightarrow v$ . Allow $\pm$ N2L. Must use <b>their</b> <i>new</i> accn. Allow only sign errors. cao	4 18

(i)Using $s = ut + 0.5u^2$ with $u = 10$ and $a = -10$ E1Must be clear evidence of derivation of $-5$ . Accept one calculation and no statement about the other.(ii)either $s = 0$ gives $10t - 5t^2 = 0$ so $5t(2 - t) = 0$ Time to highest point is given by $0 = 10 - 10t$ Time to highest point is given by $0 = 10 - 10t$ Time to flight is $2 \times 1$ $= 2 \times 1$ B1 M1 Tactorising Avard 3 marks for $t = 2$ seen WWW(iii)either s $40 < 70$ , hits the groundB1 E1Factorising Award 3 marks for $t = 2$ seen WWW(iii)need $10t - 5t^2 = -15$ Solving $t^2 - 2t - 3 = 0$ so $(t-3)(t+1) = 0$ and $t = 3$ range is $60 \text{ m}$ B1 E1FT $20 \times$ their $t$ Must be clear. FT their range.(iii)need $10t - 5t^2 = -15$ Solving $t^2 - 2t - 3 = 0$ so $(t-3)(t+1) = 0$ and $t = 3$ range is $60 \text{ m}$ E1Must be clearling to solution of a quadratic. Equivalent form will do. Obtaining $t = 3$ . Allow no reference to the other root. [Avard SC3 if $t = 3$ seen WWW] Range is $20 \times$ their $t$ (provided $t > 0$ ) cao. CWO.(iv)Using (ii) & (iii), since $40 + 60 > 70$ , paths cross (For $0 < t \le 2$ ) both have same vertical motion so B is always $15 \text{ m}$ above AE1Must be convincing. Accept sketches. To a $2.75 = 15 + 55 = 70$ so true(v)Need x components summing to 70 $20 \times 0.75 + 20 \times 2.75^2 + 15 = 4.6875$ $10 \times 0.75 - 5 \times 0.75^2 = 4.6875$ M1May be implied. E1 Or correct derivation of $0.75 \text{ so} 2.75 \text{ s}$ M1 addition ( $2 \times 2.75 - 5 \times 0.75^2 = 4.6875$ M1 advalues correct. [Using cartesian equation: B1, B1 each equation: M1 $0 \times 0.75 - 5 \times 0.75^2 = 4.6875$ M1 advalues corr	Q 8		mark		sub
(ii)either s = 0 gives $10r - 5r^2 = 0$ so $5r(2-r) = 0$ B1 M1so $t = 0$ or 2. Clearly need $t = 2$ or Time to highest point is given by $0 = 10 - 10t$ A1M1Time to highest point is given by $0 = 10 - 10t$ M1M1Dep on $1^{st}$ M1. Doubling their $t$ . Properly obtainedM1M1M2Dep on $1^{st}$ M1. Doubling their $t$ . Properly obtainedM1M1M2Norizontal range is 40 m as $40 < 70$ , hits the ground(iii)need $10r - 5r^2 = -15$ Solving $r^2 - 2r - 3 = 0$ so $(r - 3)(t + 1) = 0$ and $t = 3$ (iii)need $10r - 5r^2 = -15$ Solving $r^2 - 2r - 3 = 0$ so $(r - 3)(t + 1) = 0$ and $t = 3$ (iv)Using (ii) & (iii), since $40 + 60 > 70$ , paths cross (For $0 < t \le 2$ ) both have same vertical motion so B is always 15 m above A(iv)Need x components summing to 70 $20 \times 0.75 + 20 \times 2.75 = 15 + 55 - 70$ so true(v)Need x components the same $10 \times 2.75 - 5 \times 2.75^2 + 15 = 4.6875$ (v)Need x components the same $10 \times 0.75 - 5 \times 0.75^2 = 4.6875$ (v)Need y components the same $10 \times 0.75 - 5 \times 0.75^2 = 4.6875$ M1Attempt to use 0.75 and 2.75 in two vertical height equinal and 2.75 each substituted in the appropriate equinal equinal and 2.75 each substituted in the appropriate equinal equinal and 2.75 each substituted in the appropriate equinal equinal and 2.75 each substituted in the appropriate equinal and 2.75 each substituted in the appropriate equinal and 2.75 each substituted in the appropriate equinal(v)Need x components the same $10 \times 0.75 - 5 $	(i)	Using $s = ut + 0.5at^2$ with $u = 10$ and $a = -10$	E1	Must be clear evidence of derivation of – 5. Accept one calculation and no statement about the other.	1
(iii)need $10t - 5t^2 = -15$ MI[May divide flight into two parts]Solving $t^2 - 2t - 3 = 0$ M1Equate $s = -15$ or equivalent. Allow use of $\pm 15$ .Solving $t^2 - 2t - 3 = 0$ M1Mthod leading to solution of a quadratic.so $(t - 3)(t + 1) = 0$ and $t = 3$ A1Obtaining $t = 3$ . Allow no reference to the other root.range is 60 mA1Obtaining $t = 3$ . Allow no reference to the other root.(iv)Using (ii) & (iii), since $40 + 60 > 70$ , paths crossE1(iv)Using (ii) & (iii), since $40 + 60 > 70$ , paths crossE1(iv)Using (ii) & (iii), since $40 + 60 > 70$ , paths crossE1(iv)Using (ii) & (iii), since $40 + 60 > 70$ , paths crossE1(iv)Using (ii) & (iii), since $40 + 60 > 70$ , paths crossE1(v)Need x components summing to $70$ Do not accept evaluation at one or more points alone. That B is always above A must be clear.(v)Need x components the same $10 \times 2.75 - 5 \times 2.75^2 + 15 = 4.6875$ M1 $10 \times 0.75 - 5 \times 0.75^2 = 4.6875$ B1 $10 \times 0.75 - 5 \times 0.75^2 = 4.6875$ B1 $10 \times 0.75 - 5 \times 0.75^2 = 4.6875$ E1N1Solving: A1 correct point of intersection: E1 Verify	(ii)	either $s = 0$ gives $10t - 5t^2 = 0$ so $5t(2-t) = 0$ so $t = 0$ or 2. Clearly need $t = 2$ or Time to highest point is given by $0 = 10 - 10t$ Time of flight is $2 \times 1$ = 2 s horizontal range is 40 m as 40 < 70, hits the ground	B1 M1 A1 M1 A1 B1 E1	Factorising Award 3 marks for $t = 2$ seen WWW Dep on 1 <sup>st</sup> M1. Doubling <b>their</b> $t$ . Properly obtained FT 20 × <b>their</b> $t$ Must be clear. FT <b>their</b> range.	
(iv)Using (ii) & (iii), since $40 + 60 > 70$ , paths cross (For $0 < t \le 2$ ) both have same vertical motion so B is always 15 m above AE1Must be convincing. Accept sketches.(v)Need x components summing to 70 $20 \times 0.75 + 20 \times 2.75 = 15 + 55 = 70$ so trueM1 E1May be implied. Or correct derivation of 0.75 s or 2.75 s(v)Need y components the same $10 \times 2.75 - 5 \times 2.75^2 + 15 = 4.6875$ $10 \times 0.75 - 5 \times 0.75^2 = 4.6875$ M1 E1May be implied. Or correct derivation of 0.75 and 2.75 in two vertical height equations (accept same one or wrong one) 0.75 and 2.75 each substituted in the appropriate equin B1E1Not values correct. [Using cartesian equation: B1, B1 each equation: M1 solving: A1 correct point of intersection: E1 Verify	(iii)	need $10t - 5t^2 = -15$ Solving $t^2 - 2t - 3 = 0$ so $(t - 3)(t + 1) = 0$ and $t = 3$ range is 60 m	M1 M1 A1 M1 A1	[May divide flight into two parts] Equate $s = -15$ or equivalent. Allow use of $\pm 15$ . Method leading to solution of a quadratic. Equivalent form will do. Obtaining $t = 3$ . Allow no reference to the other root. [Award SC3 if $t = 3$ seen WWW] Range is $20 \times$ <b>their</b> $t$ (provided $t > 0$ ) cao. CWO.	5
(v)Need x components summing to 70 $20 \times 0.75 + 20 \times 2.75 = 15 + 55 = 70$ so trueM1 E1May be implied. Or correct derivation of 0.75 s or 2.75 sNeed y components the same $10 \times 2.75 - 5 \times 2.75^2 + 15 = 4.6875$ $10 \times 0.75 - 5 \times 0.75^2 = 4.6875$ M1 B1Attempt to use 0.75 and 2.75 in two vertical height equations (accept same one or wrong one) 0.75 and 2.75 each substituted in the appropriate equn B1B1 B1 B1 Net with the same $0.75 - 5 \times 0.75^2 = 4.6875$ B1 B1 B1 B1 B1 B1 Correct derivation of 0.75 s or 2.75 s	(iv)	Using (ii) & (iii), since $40 + 60 > 70$ , paths cross (For $0 < t \le 2$ ) both have same vertical motion so B is always 15 m above A	E1 E1	Must be convincing. Accept sketches. Do not accept evaluation at one or more points alone. That B is <i>always</i> above A must be clear.	2
times]	(v)	Need x components summing to 70 $20 \times 0.75 + 20 \times 2.75 = 15 + 55 = 70$ so true Need y components the same $10 \times 2.75 - 5 \times 2.75^2 + 15 = 4.6875$ $10 \times 0.75 - 5 \times 0.75^2 = 4.6875$	M1 E1 M1 B1 E1	May be implied. Or correct derivation of 0.75 s or 2.75 s Attempt to use 0.75 and 2.75 in two vertical height equations (accept same one or wrong one) 0.75 and 2.75 each substituted in the appropriate equn Both values correct. [Using cartesian equation: B1, B1 each equation: M1 solving: A1 correct point of intersection: E1 Verify times]	5